National Conference on Recent Advances in Computer Science and IT (NCRACIT)
International Journal of Scientific Research in Computer Science, Engineering and Information Technology
© 2018 IJSRCSEIT | Volume 4 | Issue 1 | ISSN : 2456-3307

Evolution of Mobile Wireless Communication Systems from 1G to 5G : A Comparative Analysis

Majid Irfan Baba[1], Naira Nafees[2], Insha Manzoor[3], Kamran Aijaz Naik[4], Suhaib Ahmed[5]

[12345]Department of Electronics and Communication Engineering, Baba Ghulam Shah Badshah University, Rajouri, J&K, India

ABSTRACT

In this paper, the evolution of mobile wireless technology from 1G to 5G has been summarized along with their virtues and drawbacks. Further, the architecture and applications of 5G and various challenges which are being faced in its deployment has been discussed. In addition to this, some of the various techniques which are expected to be used in the success of 5G and its implementation are explored. Finally a comparative analysis of how 5G is different from current generation and why it is needed is also presented.

Keywords: 1G, 2G, 3G, 4G, 5G, Architecture, IPv6, MIMO

I. INTRODUCTION

Wireless network refers to any type of network that is not connected with the help of cables. Wireless communication has become very pervasive with tremendous growth in technology day-by-day. Significant research efforts have been made in the previous years which intend to develop new wireless capacity through the implementation of much more intelligence in wireless networks. Even after the onset of wireless technology, the problems and obstacles in the efficient communication are still encountered. The number of mobile phones and internet users has increased significantly in recent years and this has led to the overcrowding of network, low connectivity speed and low bandwidth. With no wireless networks, high speed internet, wireless networking on cell phones which are of greater importance on a daily basis would not have been achievable [3].

Wireless communication has started in early 1970s and in the next four decades, mobile wireless technology has underwent a gigantic transformation from 1G to 5G and each generation has made its own progression. 1st generation (1G) wireless networks were targeted primarily for voice calls without data services [1, 5, 12, 13].

This generation based on Analog technology was introduced in 1982. In 1990s the first digital cellular system was introduced called as 2nd Generation system. These offered enhanced spectrum efficiency than 1G system. The further progresses in 2G wireless communication system are 2.5G and 2.75G. 2G has speed of about 64 kbps and rest of the two provided a speed of about 144 kbps. 3G technology introduced around the year 2000, used packet switching technique for sending data in high speed. This technology allowed data rate up to 14 Mbps. 4G technology introduced in 2011, offers data rate of around 1000 Mbps to 1Gbps. The main benefit of 4G system is that these are less expensive. 5G technology provides a number of notable benefits compared to the earlier generations to provide completely wireless internet in the real sense of the word. In

order to accomplish this cause successfully, new methods will be called for. It would be implemented by the year 2020. It has a very high bandwidth that the user will have never experienced before. This makes 5G technology dominant than the preceding generations. It will be enormously in demand in the times to come and a vast transformation will take place. 5G technology would bring an important revolution and provide additional advantages to the world. Fig.1. depicts various wireless generations. [1, 2, 4, 13]

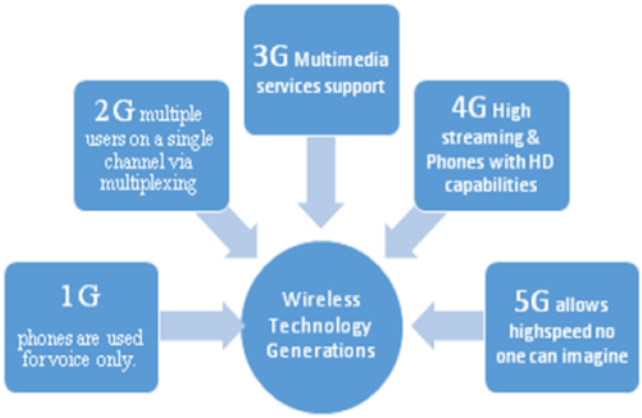

Figure 1. Illustration Of Different Wireless Technologies

II. EVOLUTION FROM 1G TO 4G

A. 1G (FIRST GENERATION)

1G emerged in 1980's and used technique like FDMA (Frequency Division Multiple Access) and it contained Analog system. FDMA is a technique in which frequency allocated for wireless communication is divided in many channels and each channel is capable of carrying a data signal. New technologies like Mobile Telephone System (MTS), Advanced Mobile Telephone System (AMTS), and Push to Talk (PTT) etc. were introduced in 1G. With channel capacity of 30 KHz it provided speed up to 2.4kbps. Users could only manage to call only in one country. It had no security and poor voice quality with very low spectrum efficiency. Further the size of mobile phone was big and it was a hectic job to carry them all the time. There was something to be done by the network operators and soon they came up with 2G in the market [2, 4, 10].

B. 2G (Second Generation)

Emerging in late 1980's based on GSM (Global System for Mobile Communication) used digital signal over Analog signal as in 1G, thus making it more secure by enabling digital encryption. Its main aim was to deliver services like Text, Pictures, SMS, e-mails etc. It used the Bandwidth of 30 to 200 KHz with data rate of 64kbps.Users were still not satisfied with the provided data rate by operators as downloading was an issue and browsing speed was low as well. So, later 2.5G and 2.75 were introduced so data rate could be increased in which techniques like GPRS (General Packed Radio Service), CDMA (Code Division Multiple Access), EDGE (Enhanced Data rates for GSM Evolution) were used. Data rates were increased from 64kbps in 2G to 144kpbs and 180kbps in 2.5G and 2.75G respectively, hence providing users with more browsing speed and allowing downloading of mp3 songs. Although, lot of things like security, speed, and voice quality were improved in 2G but there was still lot to do yet and researchers were still working to formulate better techniques and provide better services. Also, 2G was unable to handle complexity in data like videos and if there is no network coverage in any specific area, digital signals would be weak. These issues became root cause for rise of 3G [2, 3, 4, 13].

C. (THIRD GENERATION)

3G was launched in around 2000 and it mainly targeted for increase in the data rate speed. It is three times better than GSM i.e. 3GSM. It uses packet switching technique and Wide Band Wireless Network which provided Global access and more clarity. It is called UMTS (Universal Mobile Telecommunication System) in Europe and CDMA2000 in America. It Operates at the range of 2100MHz and has bandwidth of 15-20MHz for high speed internet. It provides speed of around 125kbps to 2Mbps for faster downloading, thus also enabling clear and continuous voice and video calling. It also

supported 3D gaming, Mobile TV, MMS, Live streaming, sending/receiving large e-mails etc. Further new techniques were developed and 3.5G was also introduced which was six times faster than UMTS. It was having data rate in-between 5-30Mbps and techniques like W-CDMA, WLAN, and HSDPA were used. 3G consumed more power than 2G and also network plans were expensive compared to 2G. Also, 3G mobile phones were costly and it was having higher bandwidth requirement which gave an edge for bringing 4G into the play [2, 3, 4, 6].

D. 4G (FOURTH GENERATION)

LTE (Long Term Evolution) is considered as 4G. It offers downloading speed up to 100Mbps. Launched in 2012, 4G provides additional service over 3G like Multi-Media Newspaper, TV programming with more clarity, High Quality live streaming, HDTV, location based services, video chatting, Digital Video Broadcasting (DVB), expanded multimedia services and seamless browsing with high speed. Apart from this, battery efficiency is increased and it has low cost per bit. 4G has been developed to accommodate the QoS (Quality of Service).It has ultra-low latency compared to 3G, about 50 milliseconds latency rate. It takes only 6 minutes to download High Definition movie. 4G has complicated hardware and expensive equipment's are required to implement next generation network [2, 4, 12].

E. Need For 5G

We are moving towards the new era and we need wireless technologies to communicate with each other, although we have 4G technology right now to communicate but still there are few disadvantages in 4G technology. So we came forward with the new technology known as 5G technology.

One of the main benefits of the 5G technology will not only be its speed but also the rate of latency which makes it reliable and different from other technologies. The forthcoming Ultra-Low-Latency of 5G technology will have the range between 1ms and 10ms. This allows a user to go for live streaming with no delay at all [14].

- High quality voice and video calling with more clarity.
- Highly supportable to World Wide Wireless Web, so completely wireless.
- Ultra-low latency, 1millisecond latency rate.
- Uploading and Downloading touching skies, users will get insane.
- Bi-directional large bandwidth sharing.
- Offers global access and service portability.
- It has Error control mechanism.
- Low battery consumption i.e. 90% decrease in network energy usage.
- Have AI (Artificial intelligence) capabilities.
- Promises better Quality of services (QoS).
- Remote diagnostic is a great feature, so better and fast solutions.
- We can access our laptops, PC's, cars and bikes etc. from our mobile phone.
- It also has expanded coverage [1, 4, 11].

There will also be many changes in 5G which will evolve when the technology come into the existence in year 2020, for now we can just imagine what will be provided to us.

F. CHALLENGES FROM 4G TO 5G

Challenges are the natural part of the new development; so like all technologies, 5G also has to face the natural challenges. As we look back into time, we find very fast growth of technologies. The journey from 1G to 5G is nearly about 40 years old (considering 1G in 1980's and 5G are expected to be in 2020). Despite, in this long journey, the familiar challenges that we have recognized are lack of infrastructure, research methodology, and cost.

To understand these challenges of 5G you need to look below:

- Inter-Cell Interference: This is the main technological issue that that needed to be solved. There are variations in size of

traditional macro cells and concurrent small cells that will lead to interference.

- Infrastructure: Researchers are facing technological challenges of standardization and application of 5G service.
- Security and Privacy: This is one of the crucial challenges that 5G technology needs to provide the protection of personal data
- Legislation of Cyber law: cybercrime and other misrepresentation also geared up with hoax free 5G technology.
- Communication, Navigation, & Sensing: These supplies are fully depends on the availability of the radio spectrum, through which signals are transmitted. Though the 5G technology has the great computational power for the transmission of huge volume of data which are coming from different sources, but it needs large infrastructure support.
- Obstacles: Like buildings, trees and even bad weather can also cause interference. To remove this, carriers will need to install more base stations to give best coverage, and carriers should use antenna technologies like MIMO

Common Platform: There needs to be one familiar governing body, which can set a common platform for all engineering practices to adjust the interconnectivity issues as well as knowledge sharing [4].

III. 5G (FIFTH GENERATION)

With an exponential increase in the demand of the users, 4G will now be easily replaced with 5G which will have existing features of 4G plus multiple extra features like high data speed and capacity with less latency, AI capabilities, large phone memory, more clarity in audio/ video and much more. 5G is expected to be the platform of WWWW (World Wide Wireless Web). It will be a real wireless network where anyone can access internet with no limits, without barrier and one will have no restrictions in terms of space and time. It will support UWB (Ultra-wideband), IPv6, BDMA (Beam division multiple access). The key technologies used for fulfilment of 5G are: Heterogeneous Networks (HetNets), MIMO (Multiple input multiple output), DAWN (Dynamic Ad-hoc Wireless network), Multi-RAT (Radio access technology). HetNets will offer a combination of macro cells, small cells and Wi-Fi networks. Multi-RAT combines LTE (Long term evolution) with new 5G technologies. The Router and switching technology used in 5G provided high connectivity [1, 2, 4, 5, 7, 8, 9].

Expected to be launched in 2020, 5G will have speed over 1gbps, although in practical it is believed to have speed up to 100Mbps. Its benefits are beyond anyone's imagination. With faster transmission than any other previous generations, it has some advanced features like supports documentation, e-payments; user can switch between multiple wireless technologies simultaneously. It has huge data capability with unrestricted calls and infinite data broadcast. High definition movies can be downloaded in 6 seconds while it takes 6 minutes for the same in current 4G network and may take more than one hour in case of 3G. Mobiles will ring according to our moods, we can even charge our phone using own heartbeat. Exact time of birth of babies will be recorded as accurately as in milliseconds. We can even be able to sense Tsunami/ Earthquakes and prevent much destruction. It will mostly take over market due to its high speed and extra advanced features and can also handle best technologies [1, 5, 10, 11].

Apart from this, 5G will offer cloud computing resources (CCR), which is convenient on-demand network access to configure computing resources like networks, services, storage etc. Cloud computing allows users to use applications without installing it. Having high bandwidth and lower latency it will supercharge AI-powered services, making them more reliable and suitable to use over broad range of situations. 5G will also play a great role in the growth IoT (Internet of things) which will need billions of connected devices and IoE (Internet of everywhere). 5G also works on QoS (Quality of Service) parameters such as delay, jitter, losses, Bandwidth, reliability. Its high speed wireless

communication will bring out a genuine life and will be helpful extremely in business sectors for operating on land, over sea as well as in the air [1, 2, 4, 11, 13].

IV. ARCHITECTURE OF 5G

To envisage 5G into market now, it is quite evident that the multiple access techniques which are prevailing in the network are at a still and in need of improvement. Technologies like OFDMA are going to prevail for almost more than 50 years from now, alternatively there could be only the addition of any application to the prevailing fundamental network to meet the user requirements.so the drastic change in the designing of 5G wireless architecture is needed. In the present architecture there are lots of penetration losses and reduced spectral and energy efficiency because for an inside mobile user to communicate with the outside user, a signal has to travel through the walls of indoors. To overcome this challenge, a new 5G cellular architecture has come into existence to separate the outside and inside setups. This is done with the help of massive MIMO technology. In this technique, an array of antennas is setup having hundreds of antenna units. With the deployment of such an architecture, the indoor users have to communicate only with the inside wireless access points while the larger antenna arrays will be installed outside the buildings. For indoor communications, the techniques that will come handy are WIFI, ultra-wide band, millimeter wave communications, visible light communications etc. but the high frequency waves cannot be used for outside communication [1, 5].

5G cellular architecture is a heterogeneous one because it contains macro as well as micro cells. Also, mobile small cell concept is its integral part for the benefit of high mobility users travelling at a fast rate. Apart from this, massive MIMO unit which consists of large arrays of antenna is for the communication with outside base station.5G architecture will be an all IP-based model for wireless and mobile networks interoperability. This IP technology ensures that there is enough control data for proper routing of IP packets which are associated with a particular connection. In 5G cellular architecture there are number of radio access technologies (RATS). These RATS act as IP link to internet world [1, 5]. The feature that makes 5G acceptable for all technologies is the flat IP network. In this network the data is no longer routed by traversing a path from central core to multilayers to a user. Instead, the flat core routers of the originating user routes data directly to target user.

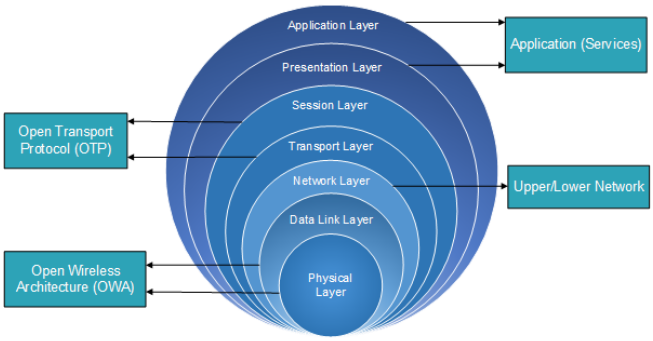

Figure 2. Layers of architecture

The network concept for 5G wireless involves the change in some of the layers of architecture of wireless model and is shown in Fig. 2.

- The physical layer and the data link layer are based on the Open Wireless Architecture (OWA). A virtualized open wireless architecture layer is designed between the physical transmission and operating system layers to make these layers independent to wireless transmission layer. The OWA virtualization defines the portable wireless air-interface modules corresponding to the physical radio transmission technologies (RTTs) to enable the flexible change of different RTTs by an external memory card and facilitates the visitor OS operable upon the host OS of the mobile terminal device to support seamless handover and switch between different OS platforms.
- The network layer in 5G architecture follows the IPv6 protocol, in which all the mobile networks will use separate mobile IP.
- The session and transport layer of normal model are replaced by Open Transfer Protocol layer in 5G cellular network [1, 11].

Among the many new concepts which are being developed for 5G network, one such concept is CRT i.e., Cognitive Radio Technique.CRT allows the user handset to choose the best radio access network and get the best connection for best performance.

Massive MIMO: In this technique, the channel response of each terminal is estimated by the base station. This forms the base of the concept of spatial multiplexing on which massive MIMO is dependent. In multi-point MIMO, the channel resources are spatially shared by users rather than an orthogonal use like in point to point MIMO as shown in Fig. 3. When the resources are spatially shared the resulting interference can be eliminated using certain precoders and decoders. Further, it depends on phase coherent signals from all antennas at the base station. This technology is very energy efficient, robust, and secure and spectrum efficient [1, 5, 14].

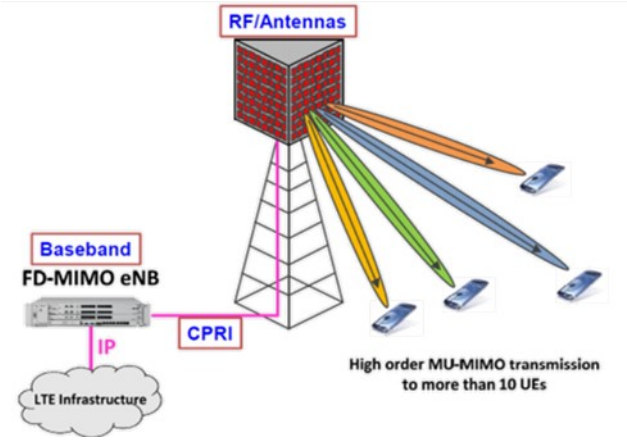

Figure 3. Spatial Multiplexing of MIMO

IPv6 Protocol: Ipv6 is 128-bits address having an address space of 2^{128}. Ipv6 address is divided into 4 parts and each part has its significance. First part is considered as home address and 2nd part as care of address.3rd part is considered for tunnelling and last part for VPN sharing. This gives a uniform voice and video and all other data services to mobile host which will be based on Ipv6. Further, Ipv6 features include:

- It has simplified header which is only twice bigger than Ipv4 provided that Ipv6 address is 4 times longer.
- It supports both stateful and stateless auto configuration mode of its host devices.
- It can take the faster routing decisions and any cast mode of packet routing.
- Ipv6 has enhanced priority support i.e., traffic class and flow label are used to tell the underlying routers how to efficiently packet the data and route it.
- It has an optional feature of Ipsec security.

5G network also follows the techniques like BDMA i.e., Beam Division Multiple Access and Filter Bank Multi carrier multiple access(FBMA) which is expected to provide a data rate of 10-50 Gbps and a frequency band of up to 1.8 to 2.6 GHz and 30-300 GHz(expected).

BDMA: Beam Division Multiple Access is a technique independent of time and frequency resources. In BDMA the base station allocates separate beam to each mobile station. This is done by dividing antenna beam according to location of mobile station. Here different beams of distinct patterns are formed using phase array antenna.

TABLE I. PERFORMANCE COMPARISON OF DIFFERENT WIRELESS TECHNOLOGIES

Technology/Features	1G	2G/2.5G	3G/3.5G	4G	5G
Started/Evolved	1970-80	1990-1999	2000-2010	2010-now	Soon (probably from 2020)
Data Rate	2Kbps	64-180 Kbps	Up to 3.6Mbps	100Mbps	Higher than 1Gbps
Technology	Analog cellular technology	Digital cellular technology	WCDMA, CDMA-2000	LAN/WAN/PAN/WLAN	LAN/WAN/PAN/WLAN, WWWW, BDMA
Multiplexing	FDMA	TDMA, CDMA	CDMA	CDMA	CDMA
Frequency Band	800MHz	850/900/1800/1900 MHz	850/900/1800/1900/2100MHz	1.8GHz,2.3GHz, 2.6GHz, 3.5GHz	1.8, 2.6GHz, and expected 30-300GHz
Primary Features	Analog Phon	Digital phone	Digital phone calls,	All IP service, Faster	High speed, High

	e Calls	calls and messaging	e-mails, Messaging, Downloading	downloading,	capacity, Live streaming with more clarity.
Weak-nesses	No security, Poor voice quality	Limited data rate, poor downloading	Failure of WAP for internet access, Expensive	Battery use is more, complicated hardware	Infrastructure, Common Platform, Security etc.

V. DISCUSSION

Moving from FDMA/TDMA to CDMA, data rates were improved, variety of features evolved, number of applications were also developed with evolving generation as shown in Table I and Fig. 4 [1, 3, 4].

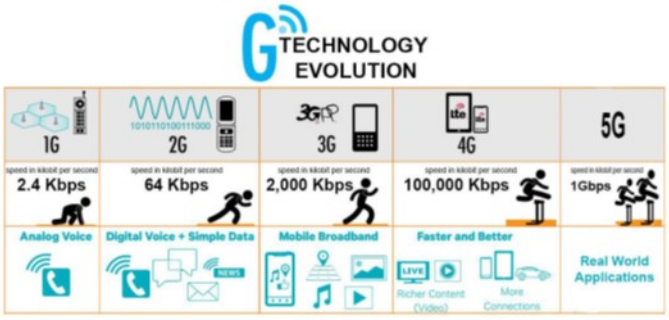

Figure 4. Technology Evolution

VI.CONCLUSION

As 4G has already been launched in many countries and its characteristics are been properly analysed so it can be further modified and give rise to next wireless generation i.e. 5G which will be using various platforms to provide us with the best features and reproduce more applications over current generations. As expected date of launching 5G is said to be 2020, so researchers need to focus more on its deployment. This paper has brought us on board about the transformation from Ipv4 to Ipv6 in 5G which is a great advancement along with the use of techniques like MIMO and BDMA. We have also discussed about the various features of 5G which will make user satisfied in all the possible ways compared to previous generations. In future, we will put light on new emerging ideas about 6G and 7G.

VII. REFERENCES

[1] Maryam Fizza, Munam Ali Shah, "5G Technology: An Overview of Applications, Prospects, Challenges and Beyond", Proc. of the IOARP International Conference on Communication and Networks (ICCN 2015),18-19 December, London, United Kingdom , 15 March 2016, pp. 94-102

[2] Ganesh R. Patil, Prof. Prashant S.Wankhade, "5G WIRELESS TECHNOLOGY", International Journal of Computer Science and Mobile Computing, vol.3, no. 10, October- 2014, pg. 203-207

[3] K. Pandya, "Comparative Study on Wireless Mobile Technology:1G, 2G, 3G, 4G and 5G", International Journal of Recent Trends in Engineering and Research, vol. 01, no. 01, pp 24-27, September-2015

[4] Lopa J. Vora, "Evolution of Mobile Generation Technology: 1G to 5G and Review of Upcoming Wireless Technology 5G", International Journal of Modern Trends in Engineering and Research, vol. 02, no. 10, pp. 281-290, October-2015

[5] Sandhya Shinde, Amruta Nikam, Swati Joshi, "An Overview of 5G Technology", International Research Journal of Engineering and Technology (IRJET), vol. 03, no. 04, pp. 2390-2394, April-2016

[6] Jay R. Churi, T. Sudhish Surendran, Shreyas Ajay Tigdi, Sanket Yewale, "Evolution of Networks (2G-5G)", Proc. of International Conference on Advances in Communication and Computing Technologies (ICACACT), 2012, pp. 8-13,

[7] Ahmed Farahat Mohamed, Amin Babiker, A. Nabi Mustafa, "Nanotechnology for 5G" , International Journal of Science and Research (IJSR), vol. 5, no. 2, pp.1044-47, February 2016

[8] Alexandros Kostopoulos, George Agapiou, Fang-Chun Kuo, Kostas Pentikousis, Antonio Cipriano, Dorin Panaitopol, Dimitri Marandin, Karol Kowalik, Konstantinos Alexandris, Chia-Yu Chang, Navid Nikaein, Mariana Goldhamer, Adrian Kliks, Rebecca Steinert, Aarne Mämmelä, Tao Chen, "Scenarios for 5G Networks: The COHERENT Approach", Proc. of 23rd International Conference on Telecommunications (ICT), 2013, pp. 1-6

[9] Asvin Gohil, Hardik Modi, Shobhit K Patel, “5G Technology of Mobile Communication: A Survey”, International Conference on Intelligent Systems and Signal Processing (ISSP), 2013, pp.288-292

[10] Mudit Ratana Bhalla, “Generations of Mobile Wireless Technology - A Survey,” International Journal of Computer Applications, vol. 5, no. 4, pp. 26-32, August 2010

[11] B. G. Evans and K. Baughan, "Visions of 4G," Electronics and Communication Engineering Journal, vol. 12, no. 6, pp. 293-303, Dec. 2000.

[12] M. G. Kachhavay, A.P. Thakare “5G Technology-Evolution and Revolution,” International Journal of Computer Science and Mobile Computing, vol. 3, no. 3, pp. 1080–1087, 2014.

[13] A. M. Mousa, “Prospective of Fifth Generation Mobile Communications,” International Journal of Next-Generation Networks, vol. 4, no. 3, pp. 11–30, Sep. 2012.

[14] E. G. Larsson, F. Tufvesson, O. Edfors, and T. L. Marzetta, ``Massive MIMO for next generation wireless systems,'' IEEE Communication. Magazine, vol. 52, no. 2, pp. 186-195, Feb. 2014.